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STANDARD HETEROSIS FOR GRAIN YIELD AND OTHER AGRONOMIC CHARACTERS IN MAIZE (*ZEA MAYS* L.) UNDER NORMAL AND MOISTURE STRESS CONDITIONS

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ABSTRACT

Maize is one of the important food and forage crops with abundant natural diversity. The exploitation of heterosis is possible only when the parents involved in the crosses differ in their combining ability. Five inbred lines were crossed with each of three testers in a line × tester design to evaluate standard heterotic effects in maize during 2009-2010. For single plant yield 14 hybrids showed positive significant standard heterosis under normal condition values ranging from 17.68 (QPM-13 X S.C.B. 7853-1) to 77.39 % (QPM-14 X S.C.B. 7853-1) over the standard check variety Co 1. The hybrid QPM-18 X Co (BC) 1 showed positive significant standard heterosis under normal condition for single plant yield and other yield contributing characters. Twelve hybrids showed positive significant standard heterosis under moisture stress condition values ranging from 5.24 (QPM-13 X S.C.B. 7853-1) to 52.37 % (QPM-18 X S.C.B. 7853-1). Therefore, these aforesaid maize hybrids are the promising genotypes in future for evolution of superior maize hybrids for rainfed maize growing situations.

INTRODUCTION

Maize (*Zea mays* L.) is one of the agronomically and nutritionally important cereal crop. It is a versatile crop with wider genetic variability and able to grow successfully throughout the world covering tropical, subtropical and temperate agro-climatic conditions. Maize production is limited by several factors including low soil fertility, little or no use of inorganic fertilizers especially nitrogen, drought, use of unimproved traditional varieties, pests and diseases (Claassen and Shaw, 1970). Drought induced yield losses can be substantial and researchers have been attempting to improve the tolerance of crops limiting supplies of water for decades. Their efforts have resulted in increased knowledge of drought tolerance and genetic improvement for stress tolerance. For the past decade, the International Maize and Wheat Improvement Centre (CIMMYT) conducted extensive research on screening and developing maize genotypes for drought tolerance using conventional methods.

The success of any breeding methods depends on the availability of genetic diversity in the base population. Utilization of diverse parents in hybridization programmes has been observed to yield better hybrids. Exploitation of heterosis is another possibility for increasing grain yield. The extent of heterosis has been measured as a superiority of hybrids over their mid parent (relative heterosis), superiority of hybrids over their better parent (Heterobeltiosis) and superior over standard parent (standard heterosis). Among the three heterosis, standard heterosis is given importance for the exploitation of heterotic vigour. The heterosis has been widely used in maize and other allied species by several workers like Devi *et al.* (2007); Alam *et al.* (2008); Pratap *et al.* (2013) and Thakare *et al.* (2013) continues to be applied in quantitative genetic studies. Hence, the present investigation was carried out to know the direction and magnitude of standard heterosis in maize under normal and moisture stress conditions.

MATERIALS AND METHODS

Five quality protein maize as lines *viz.*, QPM-6, QPM-12, QPM-13, QPM-14 and QPM-18 were crossed with three testers *viz.*, Co (BC) 1, S.C.B.1457-6 and S.C.B.7853-1 during 2009-2010. The resulting 15 hybrids and eight parents, along with standard check (Co 1) were evaluated in randomized complete block design with three replications. Each genotype was grown in three rows of five meters length and the spacing maintained was 75 cm between rows and 20 cm between plants. The moisture stress condition was artificially created through surface irrigation with regulated varied water regimes based on the climatological approaches (Mishra and Ahmed, 1985).

Observations were recorded from five randomly selected plants in each accession for ten quantitative characters such as plant height (cm), cob length (cm), cob breadth (cm), number of kernel rows, number of kernels per row, ear weight (g), 100 seed weight (g) and single plant yield (g) except days to 50 per cent tasseling and days to 50 per cent silking. These two characters were recorded on row basis. The superiority of F_1 over the standard variety was estimated as follows,

Standard heterosis (%) = $(F_1 - SV)/SV) \times 100$

F_1 = Mean of F_1 hybrid for a specific trait

SV = Mean value of standard variety

The 't' test was done to determine whether F_1 hybrid means were statistically significant from standard check (Co 1) means as follow (Wynne *et al.*, 1970).

RESULTS AND DISCUSSION

A breakthrough in maize yield and quality improvement may be possible through hybrid maize breeding programme. In the present study, the performance of experimental crosses were compared with that of the Co 1 variety for higher yield in order to estimate the magnitude of standard heterosis. Hence, the range of standard heterosis for maize under normal and moisture stress conditions are presented in Table 1 and Table 2.

For plant height, 13 hybrids showed significant positive standard heterosis over the check Co 1 with values ranging from 16.49 (QPM-14 X S.C.B.7853-1) to 57.31 % (QPM-18 X S.C.B.1457-6) under normal condition. Under the moisture stress condition all the hybrids showed significant positive standard heterosis over the check Co 1 with values ranging from 7.96 (QPM-12 X S.C.B.1457-6) to 60.78 % (QPM-18 X S.C.B.7853-1). These results are greatly supported by Appanu *et al.* (2007) and Devi *et al.* (2007) as they observed a different ratio of heterotic values for plant height in their F_1 population.

For days to 50 % tasseling, only one cross QPM-13 X S.C.B.7853-1 (4.83 %) over standard check under normal condition and four crosses under moisture stress condition exhibited significant positive standard heterosis. The range of days to 50 % tasseling varied from 3.41 (QPM-14 X Co (BC) 1) to 9.61 % (QPM-13 X S.C.B.7853-1) over the check variety under moisture deficit condition. For days to 50 % silking, only one cross QPM-13 X S.C.B.7853-1 (6.39 %) over standard check under normal condition and 11 crosses under moisture stress condition exhibited significant positive standard heterosis. The range of days to 50 % silking varied from 1.74 (QPM-14 X S.C.B.7853-1) to 11.82 % (QPM-13 X S.C.B.7853-1) over the check variety under moisture deficit condition.

The ten hybrids showed significant positive standard heterosis over the check Co 1 with values ranging from 3.92 (QPM-13 X S.C.B.1457-6) to 57.31 % (QPM-18 X S.C.B.7853-1) under normal condition. Under the moisture stress condition five hybrids showed significant positive standard heterosis with values ranging from 2.03 (QPM-14 X S.C.B.1457-6) to 13.69 % (QPM-18 X S.C.B.1457-6). For cob breadth, seven crosses under normal condition and 14 crosses under moisture stress condition exhibited significant positive standard heterosis over the check variety. For cob breadth, normal condition values varied from 4.53 (QPM-12 X Co (BC) 1) to 24.83 % (QPM-18 X S.C.B.7853-1). Under the moisture stress condition cob breadth values varied from 5.52 (QPM-6 X S.C.B.1457-6, QPM-12 X Co (BC) 1 and QPM-14 X Co (BC) 1) to 18.31 % (QPM-18 X S.C.B.7853-1). These results were in confirmation with Ram Reddy *et al.* (2011) and Bhavana *et al.* (2011).

The range of standard heterosis for number of kernel rows and number of kernels per row varied from -18.41 (QPM-12 X S.C.B.1457-6) to 11.04 % (QPM-14 X Co (BC) 1) and -33.88 (QPM-6 X Co (BC) 1) to 33.98 % (QPM-18 X S.C.B.7853-1) under normal condition and -17.09 (QPM-12 X S.C.B.1457-6) to 8.74 % (QPM-12 X S.C.B.1457-6) and -3.25 (QPM-6 X Co (BC) 1) to 57.24 % (QPM-18 X S.C.B.7853-1) under the moisture stress condition over the standard check, respectively. The present results are in confirmed with the findings of Tollenaar *et al.* (2004) and Alam *et al.* (2008) who also observed varying levels of standard heterosis for number of kernel rows and number of kernels per row in F_1 studies.

For ear weight, all the hybrids except QPM-12 X Co (BC) 1 showed significant positive standard heterosis under normal condition with values ranging from 13.49 (QPM-13 X S.C.B.1457-6) to 64.02 % (QPM-18 X S.C.B.7853-1). Thirteen hybrids showed significant positive standard heterosis under moisture stress condition values varied from 3.85 (QPM-13 X

Table 1: Standard heterosis for different yield traits in maize under normal condition

Hybrids	Plant height (cm)	Days to 50% tasseling	Days to 50% silking	Cob length (cm)	Cob breadth (cm)	No. of kernel rows	No. of kernels per row	Ear weight (g)	100 Seed Weight (g)	Single plant yield (g)
QPM-6 X Co (BC) 1	7.76^{ns}	-4.02**	-5.25**	-3.94**	-3.85**	-3.63**	-33.88**	-4.04**	31.06**	-17.80**
QPM-6 X S.C.B.1457-6	29.90**	-10.87**	-10.57**	-7.56**	-6.57**	-2.04**	7.09**	22.37**	25.75**	30.96**
QPM-6 X S.C.B. 7853-1	38.43**	-13.71**	-14.00**	-4.61**	-1.58^{ns}	-0.34**	11.29**	29.51**	36.41**	46.66**
QPM-12 X Co (BC) 1	23.99**	-19.18**	-20.69**	10.23**	4.53**	-3.58**	4.46**	16.61**	22.16**	22.85**
QPM-12 X S.C.B.1457-6	9.57^{ns}	-12.49**	-10.03**	13.10**	9.06**	-18.41**	21.50**	42.11**	37.55**	33.20**
QPM-12 X S.C.B. 7853-1	18.24**	-5.34**	-5.38**	19.47**	19.09**	-2.96**	-1.08**	32.89**	31.60**	28.84**
QPM-13 X Co (BC) 1	19.49**	-4.00**	-3.53**	12.53**	9.74**	-1.70**	14.56**	51.65**	41.68**	51.89**
QPM-13 X S.C.B.1457-6	41.84**	-1.99**	-3.44**	3.92**	-1.66^{ns}	-1.68**	8.05**	13.49**	11.82**	19.46**
QPM-13 X S.C.B. 7853-1	42.98**	4.83**	6.39**	-0.59**	4.75**	-4.17**	8.32**	15.34**	14.43**	17.68**
QPM-14 X Co (BC) 1	29.29**	-0.12^{ns}	-0.07^{ns}	-2.96**	-1.81^{ns}	-15.70**	23.11**	27.13**	31.60**	37.48**
QPM-14 X S.C.B.1457-6	52.76**	-3.40**	-3.73**	14.35**	0.45^{ns}	-17.83**	27.89**	17.71**	25.84**	24.42**
QPM-14 X S.C.B. 7853-1	16.49**	-1.77**	-1.88**	21.71**	1.89^{ns}	-0.04^{ns}	28.24**	50.20**	41.74**	77.39**
QPM-18 X Co (BC) 1	49.98**	-4.10**	-3.48**	17.88**	18.49**	11.04**	5.76**	29.05**	30.63**	51.26**
QPM-18 X S.C.B.1457-6	57.31**	-7.24**	-7.11**	23.32**	-1.66^{ns}	-4.05**	33.35**	40.54**	25.70**	56.27**
QPM-18 X S.C.B. 7853-1	56.98**	-2.09**	-2.30**	33.19**	24.83**	-1.50**	33.98**	64.02**	35.84**	75.61**

Table 2: Standard heterosis for different yield traits in maize under moisture stress condition

Hybrids	Plant height (cm)	Days to 50% tasseling	Days to 50% silking	Cob length (cm)	Cob breadth (cm)	No. of kernel rows	No. of kernelsper row	Earweight (g)	100 Seed Weight (g)	Single plant yield (g)
QPM-6 X Co (BC) 1	28.34**	0.02^{ns}	5.26**	-14.74**	15.11**	-4.34**	-3.25**	-6.46**	-3.87**	-11.29**
QPM-6 X S.C.B.1457-6	31.51**	-3.10**	0.03^{ns}	-21.84**	5.52**	-5.74**	43.25**	6.59**	-7.55**	17.54**
QPM-6 X S.C.B. 7853-1	35.61**	-8.19**	-3.61**	-14.74**	16.71**	-3.14**	23.90**	12.66**	0.32^{ns}	22.25**
QPM-12 X Co (BC) 1	22.00**	-13.20**	-6.84**	-5.60**	5.52**	-3.34**	29.47**	9.62**	-9.96**	16.47**
QPM-12 X S.C.B.1457-6	7.96**	-4.46**	0.03^{ns}	-2.55**	11.11**	8.74**	15.57**	29.24**	1.19**	23.85**
QPM-12 X S.C.B. 7853-1	19.64**	-1.92**	3.20**	2.52**	15.11**	-15.82**	23.70**	27.61**	-3.19**	5.40**
QPM-13 X Co (BC) 1	17.09**	-3.62**	4.99**	-6.61**	8.71**	-0.27^{ns}	24.27**	41.32**	3.99**	27.26**
QPM-13 X S.C.B.1457-6	43.75**	-1.22**	8.46**	-12.71**	7.11**	-17.09**	43.21**	0.50^{ns}	-17.82**	1.80^{ns}
QPM-13 X S.C.B. 7853-1	45.49**	9.61**	11.82**	-16.77**	17.59**	-3.00**	23.66**	3.85**	-15.80**	5.24**
QPM-14 X Co (BC) 1	28.34**	3.41**	5.33**	-6.09**	5.52**	-15.95**	28.62**	8.86**	-3.28**	6.53**
QPM-14 X S.C.B.1457-6	51.52**	-0.26^{ns}	4.08**	2.03**	10.31**	-15.15**	56.91**	5.51**	-7.55**	12.29**
QPM-14 X S.C.B. 7853-1	16.03**	-1.71**	1.74**	0.49^{ns}	8.71**	-16.82**	55.98**	44.76**	4.35**	31.85**
QPM-18 X Co (BC) 1	54.38**	4.39**	5.97**	9.63**	7.11**	-5.67**	40.16**	21.56**	-3.91**	27.91**
QPM-18 X S.C.B.1457-6	57.61**	-0.14^{ns}	3.93**	13.69**	-3.28**	-3.87**	52.60**	31.26**	-7.55**	35.94**
QPM-18 X S.C.B. 7853-1	60.78**	3.83**	8.46**	4.55**	18.31**	-4.41**	57.24**	59.80**	-0.20^{ns}	52.37**

* Significant at 5% level,** Significant at 1% level, ns – Non significant

S.C.B.1457-6) to 59.80 % (QPM-18 X S.C.B.7853-1) respectively. For 100 seed weight, all the hybrids showed significant positive standard heterosis under normal condition with values ranging from 11.82 (QPM-13 X S.C.B.1457-6) to 41.74 % (QPM-14 X S.C.B.7853-1). Only three hybrids showed significant positive standard heterosis under moisture stress condition values ranged from 1.19 (QPM-12 X S.C.B.1457-6) and 4.35 % (QPM-14 X S.C.B.7853-1) respectively. Present results are in agreement with the findings of Devi *et al.* (2007) who observed varying degree of heterosis for 100 grain weight in F_1 studies.

Grain yield, a quantitative trait, is itself regulated by various processes of growth, differentiation, including phenology of grain yield formation. It has been customary to consider yield as a single character even though it comprises several components and each contributing to the final expression of grain yield. For single plant yield 14 hybrids showed positive significant standard heterosis under normal condition values ranging from 17.68 (QPM-13 X S.C.B. 7853-1) to 77.39 % (QPM-14 X S.C.B. 7853-1) and 12 hybrids showed positive significant standard heterosis under moisture stress condition values ranging from 5.24 (QPM-13 X S.C.B. 7853-1) to 52.37 % (QPM-18 X S.C.B. 7853-1). These results are generally analogous to the findings of Premalatha *et al.* (2011) observed a different ratio of heterotic values for grain yield per plant in their F_1 population. These crosses will be considered for finding transgressive segregants in late segregating generations to develop a maize variety with drought tolerant and yield improvement.

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